DESIGN METHODS FOR VENTILATION SYSTEMS IN RESIDENTIAL AND COMMERCIAL BUILDINGS

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ABSTRACT

The development of guidelines for smart innovative mechanical ventilation systems is a task included in an ongoing research project partly supported by the European Commission in the framework of the Joule programme "TIPVENT – Towards Improved Performances of mechanical VENTilation systems". Before starting the actual work with the guidelines a survey was carried out to determine the level of current design methods for ventilation systems in the participating countries (Belgium, France, Great Britain, the Netherlands, Portugal, Sweden and Switzerland).

A simplified questionnaire was developed and sent to the participating countries. Examples of questions are: current traditional design procedure, whether indoor air quality and energy is taken into account by the HVAC-designer, rules of thumb, handbooks, guidelines, design tools and computer software.

The conclusions are that current traditional design often involves simple calculations, rules of thumb and manufacturers' design programs and catalogues. Traditional design seldom involves advanced calculations. Many different handbooks and guidelines are also used. These are some of the reasons why innovative ventilation systems are seldom introduced.

In the paper the current design methods are presented and discussed.

INTRODUCTION

The development of guidelines for smart innovative mechanical ventilation systems is a task included in an ongoing research project supported by the European Commission within the framework of the Joule programme "TIPVENT - Towards Improved Performances of Mechanical VENTilation Systems" (1). The aim of TIPVENT is to promote improved performances of mechanical ventilation systems and the introduction and wider use of innovative designs. The development of performance oriented procedures for designing, commissioning and maintaining mechanical ventilation systems plays a central role in the project. There are seven different tasks: impact of ventilation requirements on energy demand, field evaluation of system performances, performance approach – existing situation, performance approach – new procedures, performance approach – checking in practice (i.e.

guidelines for design, commissioning, operation and maintenance of smart innovative ventilation systems), development of smart systems and concepts for improved performances – application of developed approach and dissemination. The participating countries are Belgium, France, Great Britain, the Netherlands, Portugal, Sweden and Switzerland.

Due to an increase in mould growth and condensation problems and later on because of concerns about the indoor air quality in buildings, the use of ventilation systems has become more and more common. Ventilation of course results in an increased use of energy use for heating and sometimes for warmer climates also for cooling. Consequently ventilation may in e. g. office buildings with high internal loads actually reduce the energy use for cooling. The real performances of mechanical ventilation systems do often not meet the requirements/design specifications and do not always fulfil the expectations of the users.

The first task before developing the above mentioned performance oriented procedures is to well establish the status today in relevant areas. Therefore, before starting the actual work with the guidelines, a survey was carried out to determine and analyse the current design methods in the participating countries (2).

METHODS

A simplified questionnaire was developed to determine the level of current traditional design methods in the participating countries. It was assumed that traditional design procedure applies to competent designers, i.e., those who are able to produce good designs that meet or surpass initial expectations. This excludes explicitly those who simply get a building design from the architect, make no load calculations except some rough rule of thumb, and proceed with a totally empirical design that may or may not be the most suitable for the particular application. This latter mode would be the most common method for the low-end of the market i.e. small installers responding directly to the orders of individual clients without the intervention of an HVAC designer, or to an architect in a small project (e. g. a residence or a small office) not involving any HVAC engineer. In each participating country several designers were interviewed using the following outline:

Traditional design procedure for residential buildings

Activity	**Method**
1. Air flow rates are determined	
2. A system is chosen	
3. The location of ventilation ducts and fans, the size of the fan are determined	
4. Pressure drop calculations incl. choice of air terminal devices	
5. Noise levels are determined	
6. Drawings are made	

Traditional design procedure for commercial buildings

Activity	**Method**
1. Air flow rates are determined	
2. The need for a mechanical cooling system	
3. A system is chosen	
4. The location of ventilation ducts and fans, the size of the fan are determined.	
5. Pressure drop calculations incl. choice of air terminal devices	
6. Noise levels are determined	
7. Drawings are made	

Whether indoor air quality and energy use are issues considered, above the national requirements and/or standards, by the designer or not was documented.

Other aspects which were documented:

- Typical rules of thumb
- Common handbooks and guidelines
- Common tools
- Common software

RESULTS

Traditional design procedure for residential buildings

For most residential buildings in the participating countries the current traditional design of ventilation systems is mostly based on the size of the building, number of rooms and usage of the rooms. Air flow rates are determined from building regulations or informal standards. A system is chosen based on experience, rules of thumb, handbooks and/or catalogues from manufacturers. In France a central exhaust ventilation system is always chosen for multi-family housing. The sizing of the system is based on design programs from manufacturers and/or typical values for air velocities and pressure drops. Sometimes the noise levels are estimated using data from manufacturers or calculation programs from manufacturers. In Switzerland and Sweden requirements exist. Drawings are made using CAD-programs or still very often by hand. The smaller the building the simpler the design procedure usually is. In France a clear distinction between single and multi family housing is made.

Energy conservation usually has a low priority among HVAC-designers in most countries. The building code and/or standard requirements, which differ from country to country, are of course taken into account e. g. in Sweden the required 50 % reduction of the energy use for heating the ventilation air if heating is not based on renewables. However in Switzerland a general energy concept is usually developed.

The use of electricity for mechanical ventilation is seldom taken into account by HVAC-designers. In Switzerland it is usually included in the general energy concept.

Indoor air quality is gradually becoming an issue of concern, but calculations are seldom carried out. The indoor air quality is taken into account to the extent that in regulations and standards required or recommended air flow rates are fulfilled. In Great Britain and Portugal natural ventilation systems are often chosen and mechanical ventilation (exhaust only) is usually restricted to bathrooms/toilets and kitchens, especially for single family houses.

Traditional design procedure for commercial buildings

For most commercial buildings in the participating countries the current traditional design of ventilation systems is mostly based on the planned activity in the building and in the individual rooms i. e. air flow rates in l/(s person) and $l/(sm^2)$. The air flow rates are determined from building regulations and standards. The need for a mechanical cooling system is determined i. e. whether air conditioning or comfort cooling is required or not. This will to a large extent depend on the client's preferences. In Switzerland a demand proof is required. Manual or software calculations are carried out. The calculations can be based on handbooks, programs from manufacturers or software producers. The choice of system is based on experience, handbooks, catalogues from manufacturers and/or sometimes rules of thumb. The sizing of the system is based on design programs from manufacturers and/or typical values for air velocities and pressure drops. Pressure drop calculations including choice of air terminal devices are made using computer software and/or rules of thumb, but seldom only hand calculations. The noise levels are estimated using data or calculation programs from manufacturers. Drawings are most of the time made using CAD-programs.

Energy conservation usually has a low priority among HVAC-designers in most countries, during the design of a ventilation system. The requirements, which differ from country to country, are of course taken into account e. g. in Sweden the required 50 % reduction of the energy use for heating the ventilation air if heating is not based on renewables. However in Switzerland energy is an issue of concern during the design. The use of electricity for mechanical ventilation is taken into account in Switzerland and the Netherlands, and in Sweden and France it is gradually becoming an issue of concern. In most other countries it is seldom taken into account.

Indoor air quality is gradually becoming an issue of concern, but calculations are seldom carried out. The indoor air quality is taken into account to the extent that required or recommended air flow rates are fulfilled.

Rules of thumb

Rules of thumb relating to ventilation systems are widely used. These are primarily intended to assist in the initial design, but are in practise used much wider. A typical rule of thumb in most participating countries when designing a ventilation system is the air flow rate as l/(s and person) and/or l/(s and m^2 of floor area). Another rule of thumb is a certain range of air velocity in ducts. In some countries the space requirements for the ventilation system is based on experience e. g. area of fan room as a function of air flow rate. Often assumptions are made as to pressure drop across air terminal devices and pressure drop in ducts.

Handbooks and guidelines

In addition to national building regulations and national and international standards, the designers are using a relatively wide range of guidance material. There are guidelines based on experience from different organisations e.g. from manufacturers and suppliers of building services plants, professional organisations, research institutes, testing laboratories. The guidelines range from catalogues or CD-roms from manufacturers to detailed handbooks from professional organisations.

Design Tools

Tools typically consist of calculation sheets and computer tools for standardised calculations supplied either by equipment manufacturers or independent software vendors and specific design guidance supplied by manufacturers (recommendations, diagrams, tables, etc.).

Computer software

A wide range of computer software is available. Generic examples are given here:

- Acoustics

- Building heat transfer (simplified energy calculation and dynamic energy simulation models)
- CAD
- CFD (primarily used for larger and/or complex designs with specific problems e. g. large enclosures like atria)
- Duct/diffuser sizing (often from manufacturers)
- Heating and cooling
- Infiltration
- Psychrometric design

All of the above generic software except CAD and CFD are used at times in the design of commercial buildings. CAD is used most of the time in commercial buildings. The use of CFD tends to be restricted to larger and/or more complex designs which warrant the additional time and expenditure involved. The simplified energy calculations are sometimes carried out for residential buildings. In Sweden and Switzerland drawings for residential buildings are also fairly often produced using CAD-programs.

DISCUSSION

The current traditional design procedure for residential buildings is not enough performance oriented and therefore does not really give enough encouragement to implement innovative ventilation systems. It does, however, more and more encourage the installation of mechanical ventilation systems. For commercial buildings the current traditional design procedure is also not enough performance oriented. Therefore there is also not enough encouragement to implement innovative ventilation systems, but however probably no discouragement.

Energy use usually has a low priority among HVAC-designers in most countries when designing a ventilation system in residential and commercial buildings. This is often due to the lack of life cycle perspective, instead the investment cost is considered first of all. The energy requirements in the building code, which differ from country to country, are of course taken into account.

Use of electricity for mechanical ventilation is taken into account only in commercial buildings in some countries e. g. in Switzerland and the Netherlands. In Sweden and France it is gradually becoming an issue of concern.

Indoor air quality is gradually becoming an issue of concern. Usually the indoor air quality is taken into account to the extent that in regulations and standards required or recommended air flow rates are fulfilled.

The wide use of rules of thumb means that mostly conventional ventilation systems will be implemented. What is considered to be a conventional system will of course differ from country to country and change over time.

The wide range of guidance material, tools and computer tools used for the design of ventilation systems may or may not encourage the implementation of innovative ventilation systems. It depends upon the quality of the guidance material, tools and computer tools, which is varying.

The wide range of computer software, available for the design of ventilation systems for commercial buildings, is likely to encourage the implementation of innovative ventilation systems, as a better understanding of systems can be reached.

Often a client will give the task of designing a ventilation system to the HVAC engineering firm, who offers to do the job for the lowest price. This usually excludes thorough analysis using e.g. advanced computer software and LCC (life cycle cost)-analysis, and thereby the implementation of innovative ventilation systems.

There are many ways of encouraging the implementation of innovative ventilation systems: regulations, additional financial support, education/information and market forces. In order to facilitate the implementation, a more performance oriented approach to ventilation has to be developed and implemented. To begin with the regulations and standards have to better specify the performance of ventilation systems, than is the case today. An important part of the TIPVENT-project is to develop performance oriented procedures for ventilation, not only for the design but also for the construction and the operation.

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